

## LETTERS

Edited by Jennifer Sills

## The promise of negative emissions

IN THEIR PERSPECTIVE “The trouble with negative emissions” (14 October, p. 182), K. Anderson and G. Peters assert that negative-emissions technologies are an “unjust and high-stakes gamble.” This characterization would sideline negative-emissions technologies and remove potentially important options from the portfolio for mitigating and ameliorating climate change.

As Anderson and Peters acknowledge, the remaining carbon budget is pitifully small; at the current rate, the world will blow through 600 Gt of CO<sub>2</sub> in 15 years. Dumping this much CO<sub>2</sub> in the atmosphere will almost certainly result in more than 1.5°C warming. Indeed, as advocates of a 350-ppm target point out, the remaining CO<sub>2</sub> budget could be negative.

Anderson and Peters provide no evidence that faith in negative-emissions technologies is to blame for a delay in implementing other mitigation plans or for the failure of countries to cut emissions. This failure is easily explained by the free-riding behavior of some countries (1), and taking negative-emissions technologies off the table would not make collective action any easier. Indeed, given that negative-emission technologies require financial contributions, not changes in behavior, their development and deployment may well be less vulnerable to free riding. Furthermore, we need a lot of arrows in the quiver to stand a chance of meeting the Paris targets. This was a key finding from the integrated assessment modelers (2).

Rather than dividing mitigation into competing strategies, an inclusive approach would focus on stopping climate change as fast as possible while minimizing risk to vulnerable populations and to societal stability. Negative-emission technologies are not unique in facing challenges, risks, and uncertainties. It is true that negative emissions may fall short of closing the gap, but to characterize them as a high-stakes gamble is not consistent with the facts and the plausibility of meeting the Paris goals without them. Throwing a life-preserver to a drowning victim may not assure a successful rescue, but it is not a high-stakes gamble. Offering the life-preserver is preferable



At the current rate of carbon emissions, it will be difficult to meet climate goals.

to withholding it, even though it might reduce the victim's incentive for learning how to swim.

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### Response

AS WE WROTE IN OUR Perspective, we agree with Lackner *et al.* that negative-emissions technologies should “be the subject of research, development, and potentially deployment.” We support research on the technical, environmental, social, and economic viability of negative-emissions technologies. However, we stand by our conclusion that given the breadth and depth of fundamental uncertainties associated with negative-emissions technologies (1–6), a program of timely and deep mitigation in line with 2°C budgets should assume that they will not be deployed at a large scale.

A mitigation agenda that does not rely on future large-scale application of negative-emissions technologies will require a legislative environment that

delivers profound social and behavioral change by high-emitters, rapid deployment of existing low-carbon energy technologies, and urgent research and development of new promising energy technologies, including negative-emissions technologies. If negative-emissions technologies do indeed prove to be successful, then a lower temperature rise can be subsequently pursued.

Lackner *et al.* claim that including negative-emissions technologies in assessments does not delay other mitigation tactics. On the contrary, evidence indicates that an assumption of negative-emissions success does delay conventional mitigation. Without negative-emissions technologies, much more ambitious and far reaching mitigation is required (2). The 2°C scenarios assessed by the IPCC that do not include negative emissions but do allow afforestation have considerably lower fossil-fuel consumption than scenarios that include negative emissions [e.g., Fig. S4 in (7)]. The “emissions gap” (8, 9) between the necessary level of mitigation to deliver on the Paris goals and the collective proposition of governments (i.e., the sum of the Intended Nationally Determined Contributions) would be much larger if negative emissions were excluded.

We stand by our claim that postulating large-scale negative emissions in the future leads to much less mitigation today. Negative emissions facilitate the appealing option (10) of exceeding tight carbon budgets and assuming that the debt will be paid back later. If we cannot pay back our carbon debt because the negative-emissions technologies do not deliver as planned, then we have saddled the vulnerable and future generations with the

temperatures we seek to avoid in the Paris Agreement. To use the analogy of Lackner *et al.*, we knowingly let someone jump into a raging torrent, telling them we may be able to save them with a technology we have yet to develop.

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## Keeping creationism out of classrooms

IN HIS LETTER “Institutionalizing creationism” (1), Baltzley criticized the Western Interstate Commission for Higher Education’s Interstate Passport Initiative—which will standardize curriculum objectives across a number of U.S. institutions—for including a reference to the 2014 debate between Bill Nye and Ken Ham about evolution. The faculty handbook to which Baltzley referred included the sentence, “Students evaluate the effectiveness of the use of scientific data in a debate, for example:…Students watch the Ken Hamm [sic]–Bill Nye evolution-creation science debate (available online) and evaluate the scientific evidence and arguments used by the participants.” The program’s proficiency criteria have now been revised to omit this example (2, 3).

The Passport Initiative Natural Science faculty is to be praised for its decision. Contrary to T. Krabacher and P. Flatt’s defense of the curriculum (“Passport Initiative fosters applied science,” Letters, 19 August, p. 759), the National Center for

Science Education agrees with Baltzley. It would be a disservice to students to present Ken Ham’s young-Earth creationist views as if they were scientifically credible or even the subject of current scientific debate, and it would be a disservice to the scientific community to appear to confer any unearned scientific legitimacy to creationism. The Federation of American Societies for Experimental Biology, representing 125,000 researchers in the life sciences, agreed, urging the removal of the debate (4).

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